

## APPLICATION FOR PATENT

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TITLE: METHOD AND SYSTEM FOR RETURN OF DRILLING FLUID FROM A SEALED MARINE RISER TO A FLOATING DRILLING RIG WHILE DRILLING

## SPECIFICATION

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of co-pending U.S. Application Serial No. 09/911,295, filed July 23, 2001, now U.S. Patent No. 6,913,092, which is a continuation-in-part of U.S. Application Serial No. 09/260,642, filed March 2, 1999, now U.S. Patent No. 6,263,982, on July 24, 2001, which is a continuation-in-part of U.S. Application Serial No. 09/033,190, filed March 2, 1998, now U.S. Patent No. 6,138,774, which are incorporated herein for reference.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

[0002] The present invention relates to a method and system for a floating structure using a marine riser while drilling. In particular, the present invention relates to a method and system for return of drilling fluid from a sealed marine riser to a floating structure while drilling in the floor of an ocean using a rotatable tubular.

#### 2. Description of the Related Art

[0003] Marine risers extending from a wellhead fixed on the floor of an ocean have been used to circulate drilling fluid back to a floating structure or rig. The riser must be large enough in internal diameter to accommodate the largest bit and pipe that will be used in drilling a borehole into the floor of the ocean. Conventional risers now have internal diameters of approximately 50 centimeters (20 inches), though other diameters are and can be used.

[0004] An example of a marine riser and some of the associated drilling components, such as shown in FIG. 1, is proposed in U.S. Patent No. 4,626,135, assigned on its face to Hydril Company, which is incorporated herein by reference for all purposes. Since the riser R is fixedly connected between the floating structure or rig S and the wellhead W, as proposed in

the '135 patent, a conventional slip or telescopic joint SJ, comprising an outer barrel OB and an inner barrel IB with a pressure seal therebetween, is used to compensate for the relative vertical movement or heave between the floating rig and the fixed riser. Diverter D have been connected between the top inner barrel IB of the slip joint SJ and the floating structure or rig S to control gas accumulations in the subsea riser R or low pressure formation gas from venting to the rig floor F.

[0005] One proposed diverter system is the TYPE KFDS diverter system, previously available from Hughes Offshore, a division of Hughes Tool Company, for use with a floating rig. The KFDS system's support housing SH, shown in FIG. 1A, is proposed to be permanently attached to the vertical rotary beams B between two levels of the rig and to have a full opening to the rotary table RT on the level above the support housing SH. A conventional rotary table on a floating drilling rig is approximately 125 centimeters (49-1/2 inches) in diameter. The entire riser, including an integral choke line CL and kill line KL, are proposed to be run-through the KFDS support housing. The support housing SH is proposed to provide a landing seat and lockdown for a diverter D, such as a REGAN diverter also supplied by Hughes Offshore. The diverter D includes a rigid diverter lines DL extending radially outwardly from the side of the diverter housing to communicate drilling fluid or mud from the riser R to a choke manifold CM, shale shaker SS or other drilling fluid receiving device. Above the diverter D is the rigid flowline RF, shown configured to communicate with the mud pit MP in FIG. 1, the rigid flowline RF has been configured to discharge into the shale shakers SS or other desired fluid receiving devices. If the drilling fluid is open to atmospheric pressure at the bell-nipple in the rig floor F, the desired drilling fluid receiving device must be limited by an equal height or level on the structure S or, if desired, pumped by a pump up to a higher level. While the choke manifold CM, separator MB, shale shaker SS and mud pits MP are shown schematically in FIG. 1, if a bell-nipple is at the rig floor F level and the mud return system is under minimal operating pressure, these fluid receiving devices may have to be located at a level below the rig floor F for proper operation. Hughes Offshore has also provided a ball joint BJ between the diverter D and the riser R to compensate for other relative movement (horizontal and rotational) or pitch and roll of the floating structure S and the fixed riser R.

[0006] Because both the slip joint and the ball joint require the use of sliding pressure seals, these joints need to be monitored for proper seal pressure and wear. If the joints need

replacement, significant rig down-time can be expected. Also, the seal pressure rating for these joints may be exceeded by emerging and existing drilling techniques that require surface pressure in the riser mud return system, such as in underbalanced operations comprising drilling, completions and workovers, gas-liquid mud systems and pressurized mud handling systems. Both the open bell-nipple and seals in the slip and ball joints create environmental issues of potential leaks of fluid.

[0007] Returning to FIG. 1, the conventional flexible choke line CL has been configured to communicate with a choke manifold CM. The drilling fluid then can flow from the manifold CM to a mud-gas buster or separator MB and a flare line (not shown). The drilling fluid can then be discharged to a shale shaker SS to mud pits and pumps MP. In addition to a choke line CL and kill line KL, a booster line BL can be used. An example of some of the flexible conduits now being used with floating rigs are cement lines, vibrator lines, choke and kill lines, test lines, rotary lines and acid lines.

[0008] Therefore, a floating rig mud return system that could replace the conventional slip and ball joints, diverter and bell-nipple with a seal below the rig floor between the riser and rotating tubular would be desirable. More particularly it would be desirable to have a seal housing, that moves independent of the floating rig or structure but with the rotatable tubular to reduce vertical movement between the rotating seal and tubular, that includes a flexible conduit or flowline from the seal housing to the floating structure to compensate for resulting relative movement of the structure and the seal housing. Furthermore, it would be desirable if the seal between the riser and the rotating tubular would be accessible for ease in inspection, maintenance and for quick change-out.

## BRIEF SUMMARY OF THE INVENTION

[0009] A system is disclosed for use with a floating rig or structure for drilling in the floor of an ocean using a rotatable tubular. A seal housing having a rotatable seal is connected to the top of a marine riser fixed to the floor of the ocean. The seal housing includes a first housing opening sized to discharge drilling fluid pumped down the rotatable tubular and then moved up the annulus of the riser. The seal rotating with the rotatable tubular allows the riser and seal housing to maintain a predetermined pressure in the fluid or mud return system that is desirable in underbalanced drilling, gas-liquid mud systems and pressurized mud handling systems. A flexible conduit or hose is used to compensate for the relative movement of the

seal housing and the floating structure since the floating structure moves independent of the seal housing. This independent movement of seal housing relative to the floating structure allows the seal rotating with the tubular to experience reduced vertical movement while drilling.

[0010] Advantageously, a method for use of the system is also disclosed.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0011] A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

FIG. 1 is an elevational view of a prior art floating rig mud return system shown in broken view with the lower portion illustrating the conventional subsea blowout preventer stack attached to a wellhead and the upper portion illustrating the conventional floating rig where a riser is connected to the floating rig and conventional slip and ball joints and diverters are used;

FIG. 1A is an enlarged elevational view of a prior art diverter support housing for use with a floating rig;

FIG. 2 is an enlarged elevational view of the floating rig mud return system of the present invention;

FIG. 3A, taken from FIG. 3 of U.S. Patent No. 5,662,181, is a quarter sectional view of a rotating blowout preventor showing top and bottom radial bearings and thrust bearings;

FIG. 3B is an enlarged view of the seal housing of the present invention positioned above the riser with the rotatable seal in the seal housing engaging a rotatable tubular;

FIG. 4 is an elevational view of a diverter assembly substituted for a bearing and seal assembly in the seal housing of the present invention for conventional use of a diverter and slip and ball joints with the riser;

FIG. 5 is the bearing and seal assembly of the present invention removed from the seal housing;

FIG. 6 is an elevational view of an internal running tool and riser guide with the running tool engaging the seal housing of the present invention;

FIG. 7 is a section view taken along lines 7-7 of FIG. 6;

FIG. 8 is an enlarged elevational view of the seal housing shown in section view to better illustrate the locating pins and latching pins relative to the load disk of the present invention.

FIG. 9 is a graph illustrating latching pin design curves for latching pins fabricated from mild steel;

FIG. 10 is a graph illustrating latching pin design curves for latching pins fabricated from 4140 steel;

FIG. 11 is a graph illustrating estimated pressure losses in a 4 inch diameter hose; and

FIG. 12 is a graph illustrating estimated pressure losses in a 6 inch diameter hose.

### DETAILED DESCRIPTION OF THE INVENTION

[0012] FIGS. 2, 3B and 6 to 8 disclose the preferred embodiment of the present invention and FIG. 4 shows an embodiment of the invention for use of a conventional diverter and slip and ball joints after removing the bearing and seal assembly of the present invention as illustrated in FIG. 5, from the seal housing, as will be discussed below in detail.

[0013] FIG. 2 illustrates a rotating blowout preventer or rotating control head, generally designated as 10, of the present invention. This rotating blowout preventer or rotating control head 10 is similar, except for modifications to be discussed below, to the rotating blowout preventer disclosed in U.S. Patent No. 5,662,181, assigned to the assignee of the present invention, Weatherford/Lamb, Inc. of Houston, Texas. The '181 patent, incorporated herein by reference for all purposes, discloses a product now available from the assignee that is designated Model 7100. The modified rotating blowout preventer 10 can be attached above the riser R, when the slip joint SJ is locked into place, such as shown in the embodiment of FIG. 2, so that there is no relative vertical movement between the inner barrel IB and outer barrel DB of the slip joint SJ. It is contemplated that the slip joint SJ will be removed from the riser R and the rotating blowout preventer 10 attached directly to the riser R. In either embodiment of a locked slip joint (FIG. 2) or no slip joint (not shown), an adapter or crossover 12 will be positioned between the preventer 10 and the slip joint SJ or directly to the riser R, respectively. As is known, conventional tensioners T1 and T2 will be used for applying tension to the riser R. As can be seen in FIGS. 2 and 3B, a rotatable tubular 14 is positioned through the rotary table RT, through the rig floor F, through the rotating blowout preventer 10 and into the riser R for drilling in the floor of the ocean. In addition to using the

BOP stack as a complement to the preventer 10, a large diameter valve could be placed below the preventer 10. When no tubulars are inside the riser R, the valve could be closed and the riser could be circulated with the booster line BL. Additionally, a gas handler, such as proposed in the Hydril '135 patent, could be used as a backup to the preventer 10. For example, if the preventer 10 developed a leak while under pressure, the gas handler could be closed and the preventer 10 seal(s) replaced.

[0014] Target T-connectors 16 and 18 preferably extend radially outwardly from the side of the seal housing 20. As best shown in FIG. 3B, the T-connectors 16, 18 comprise terminal T-portions 16A and 18A, respectively, that reduce erosion caused by fluid discharged from the seal housing 20. Each of these T-connectors 16, 18 preferably include a lead "target" plate in the terminal T-portions 16A and 18A to receive the pressurized drilling fluid flowing from the seal housing 20 to the connectors 16 and 18. Although T-connectors are shown in FIG. 3B, other types of erosion-resistant connectors can be used, such as long radius 90 degree elbows or tubular fittings. Additionally, a remotely operable valve 22 and a manual valve 24 are provided with the connector 16 for closing the connector 16 to shut off the flow of fluid, when desired. Remotely operable valve 26 and manual valve 28 are similarly provided in connector 18. As shown in FIGS. 2 and 3B, a conduit 30 is connected to the connector 16 for communicating the drilling fluid from the first housing opening 20A to a fluid receiving device on the structure S. The conduit 30 communicates fluid to a choke manifold CM in the configuration of FIG. 2. Similarly, conduit 32, attached to connector 18, though shown discharging into atmosphere could be discharged to the choke manifold CM or directly to a separator MB or shale shaker SS. It is to be understood that the conduits 30, 32 can be a elastomer hose; a rubber hose reinforced with steel; a flexible steel pipe such as manufactured by Coflexip International of France, under the trademark "COFLEXIP", such as their 5" internal diameter flexible pipe; or shorter segments of rigid pipe connected by flexible joints and other flexible conduit known to those of skill in the art.

[0015] Referring to FIG. 3A, the bearing and seal assembly 10A includes a fixed outer barrel or member 36A and the rotatable inner barrel or member 36B. Top radial bearing 80A, a pair of thrust bearings 82 and a bottom radial bearing 80B, are operably positioned between the inner barrel or member 36B and the outer barrel or member 36A.

[0016] Turning now to FIG. 3B, the rotating blowout preventer 10 of the present invention is shown in more detail and in section view to better illustrate the bearing and seal assembly 10A of the present invention. In particular, the bearing and seal assembly 10A comprises a top rubber pot 34 connected to the bearing assembly 36, which is in turn connected to the bottom stripper rubber 38. The top drive 40 above the top stripper rubber 42 is also a component of the bearing and seal assembly 10A. Although as shown in FIG. 3B the bearing and seal assembly 10A uses stripper rubber seals 38 and 42, other types of seals can be used. Stripper rubber seals as shown in FIG. 3B are examples of passive seals, in that they are stretch-fit and cone shape vector forces augment a closing force of the seal around the rotatable tubular 14. In addition to passive seals, active seals can be used. Active seals typically require a remote-to-the-tool source of hydraulic or other energy to open or close the seal. An active seal can be deactivated to reduce or eliminate sealing forces with the tubular 14. Additionally, when deactivated, an active seal allows annulus fluid continuity up to the top of the rotating blowout preventer 10. One example of an active seal is an inflatable seal. The RPM SYSTEM 3000™ from TechCorp Industries International Inc. and the Seal-Tech Rotating Blowout Preventer from Seal-Tech are two examples of rotating blowout preventers that use a hydraulically operated active seal. U.S. Patent Nos. 5,022,472, 5,178,215, 5,224,557, 5,277,249 and 5,279,365 also disclose active seals and are incorporated herein by reference for all purposes. Other types of active seals are also contemplated for use. A combination of active and passive seals can also be used.

[0017] It is also contemplated that a rotary or rotating blowout preventor, such as disclosed in U.S. Patent No. 5,178,215, could be adapted for use with its rotary packer assembly rotatably connected to and encased within the outer housing.

[0018] Additionally, a quick disconnect/connect clamp 44, as disclosed in the '181 patent and shown in FIG. 3A, is provided for hydraulically clamping, via remote controls, the bearing and seal assembly 10A to the seal housing or bowl 20. As discussed in more detail in the '181 patent, when the rotatable tubular 14 is tripped out of the preventer 10, the clamp 44 can be quickly disengaged to allow removal of the bearing and seal assembly 10A, as best shown in FIG. 5. Advantageously, upon removal of the bearing and seal assembly 10A, as shown in FIG. 4, the internal diameter HID of the seal housing 20 is substantially the same as the internal diameter RID of the riser R, as indicated in FIG. 2, to provide a substantially full bore access to the riser R.

[0019] Alternately, although not shown in FIG. 3B, a suspension or carrier ring can be used with the rotating blowout preventor 10. The carrier ring can modify the internal diameter HID of the seal housing 20 to adjust it to the internal diameter RID of the riser, allowing full bore passage when installed on top of a riser with an internal diameter RID different from the internal diameter HID of the seal housing 20. The carrier ring preferably can be left attached to the bearing and seal assembly 10A when removed for maintenance to reduce replacement time, or can be detached and reattached when replacing the bearing and seal assembly 10A with a replacement bearing and seal assembly 10A.

[0020] Returning again to FIG. 3B, while the rotating preventer 10 of the present invention is similar to the rotating preventer described in the '181 patent, the housing or bowl 20 includes first and second housing openings 20A, 20B opening to their respective connector 16, 18. The housing 20 further includes four holes, two of which 46, 48 are shown in FIGS. 3 and 4, for receiving latching pins and locating pins, as will be discussed below in detail. In the additional second opening 20B, a rupture disk 50 is preferably engineered to rupture at a predetermined pressure less than the maximum allowable pressure capability of the marine riser R. In one embodiment, the rupture disk 50 ruptures at approximately 500 PSI. In another embodiment, the maximum pressure capability of the riser R is 500 PSI and the rupture disk 50 is configured to rupture at 400 PSI. If desired by the user, the two openings 20A and 20B in seal housing 20 can be used as redundant means for conveying drilling fluid during normal operation of the device without a rupture disk 50. If these openings 20A and 20B are used in this manner, connector 18 would desirably include a rupture disk configured to rupture at the predetermined pressure less than a maximum allowable pressure capability of the marine riser R. The seal housing 20 is preferably attached to an adapter or crossover 12 that is available from ABB Vetco Gray. The adapter 12 is connected between the seal housing flange 20C and the top of the inner barrel IB. When using the rotating blowout preventer 10, as shown in FIG. 3B, movement of the inner barrel IB of the slip joint SJ is locked with respect to the outer barrel OB and the inner barrel flange IBF is connected to the adapter bottom flange 12A. In other words, the head of the outer barrel HOB, that contains the seal between the inner barrel IB and the outer barrel OB, stays fixed relative to the adapter 12.

[0021] Turning now to FIG. 4, an embodiment is shown where the adapter 12 is connected between the seal housing 20 and an operational or unlocked inner barrel IB of the slip joint



SJ. In this embodiment, the bearing and seal assembly 10A, as such as shown in FIG. 5, is removed after using the quick disconnect/connect clamp 44. If desired the connectors 16, 18 and the conduits 30, 32, respectively, can remain connected to the housing 20 or the operator can choose to use a blind flange 56 to cover the first housing opening 20A and/or a blind flange 58 to cover the second housing opening 20B. If the connectors 16, 18 and conduits 30, 32, respectively, are not removed the valves 22 and 24 on connector 16 and, even though the rupture disk 50 is in place, the valves 26 and 28 on connector 18 are closed. Another modification to the seal housing 20 from the housing shown in the '181 patent, and FIG. 3A, is the use of studded adapter flanges instead of a flange accepting stud bolts (e.g., flange 20E of FIG. 3A), since studded flanges require less clearance for lowering the housing through the rotary table RT.

[0022] An adapter 52, having an outer collar 52A similar to the outer barrel collar 36A of outer barrel 36 of the bearing and seal assembly 10A, as shown in FIG. 5, is connected to the seal housing 20 by clamp 44. A diverter assembly DA comprising diverter D, ball joint BJ, crossover 54 and adapter 52 are attached to the seal housing 20 with the quick connect clamp 44. As discussed in detail below, the diverter assembly DA, seal housing 20, adapter 12 and inner barrel IB can be lifted so that the diverter D is directly connected to the floating structure S, similar to the diverter D shown in FIG. 1A, but without the support housing SH.

[0023] As can now be understood, in the embodiment of FIG. 4, the seal housing 20 will be at a higher elevation than the seal housing 20 in the embodiment of FIG. 2, since the inner barrel IB has been extended upwardly from the outer barrel OB. Therefore, in the embodiment of FIG. 4, the seal housing 20 would not move independent of the structure S but, as in the conventional mud return system, would move with the structure S with the relative movement being compensated for by the slip and ball joints.

[0024] Turning now to FIG. 6, an internal running tool 60 includes three centering pins 60A, 60B, 60C equally spaced apart 120 degrees. The tool 60 preferably has a 49.5 cm (19.5") outer diameter and a 11.4 cm (4 1/2") threaded box connection 60D on top. A load disk or ring 62 is provided on the tool 60. As best shown in FIGS. 6 and 7, latching pins 64A, 64B and locating pins 66A, 66B preferably include extraction threads T cut into the pins to provide a means of extracting the pins with a 2.86 cm (1 1/8") hammer wrench in case the pins are bent due to operator error. The latching pins 64A, 64B can be fabricated from mild

steel, such as shown in FIG. 9, or 4140 steel case, such as shown in FIG. 10. A detachable riser guide 68 is preferably used with the tool 60 for connection alignment during field installation, as discussed below.

[0025] The conduits 30, 32 are preferably controlled with the use of snub and chain connections (not shown), where the conduit 30, 32 is connected by chains along desired lengths of the conduit to adjacent surfaces of the structure S. Of course, since the seal housing 20 will be at a higher elevation when in a conventional slip joint/diverter configuration, such as shown in FIG. 4, a much longer hose is required if a conduit remains connected to the housing 20. While a 6" diameter conduit or hose is preferred, other size hoses such as a 4" diameter hose could be used, such as discussed in FIGS. 11 and 12.

#### OPERATION OF USE

[0026] After the riser R is fixed to the wellhead W, the blowout preventer stack BOP (FIG. 1) positioned, the flexible choke line CL and kill line KL are connected, the riser tensioners T1, T2 are connected to the outer barrel OB of the slip joint SJ, as is known by those skilled in the art, the inner barrel IB of the slip joint SJ is pulled upwardly through a conventional rotary table RT using the running tool 60 removable positioned and attached to the housing 20 using the latching and locating pins, as shown in FIGS. 6 and 7. The seal housing 20 attached to the crossover or adapter 12, as shown in FIGS. 6 and 7, is then attached to the top of the inner barrel IB. The clamp 44 is then removed from the housing 20. The connected housing 20 and crossover 12 are then lowered through the rotary table RT using the running tool 60. The riser guide 68 detachable with the tool 60 is fabricated to improve connection alignment during field installation. The detachable riser guide 68 can also be used to deploy the housing 20 without passing it through the rotary table RT. The bearing and seal assembly 10A is then installed in the housing 20 and the rotatable tubular 14 installed.

[0027] If configuration of the embodiment of FIG. 4 is desired, after the tubular 14 has been tripped and the bearing and seal assembly removed, the running tool 60 can be used to latch the seal housing 20 and then extend the unlocked slip joint SJ. The diverter assembly DA, as shown in FIG. 4, can then be received in the seal housing 20 and the diverter assembly adapter 52 latched with the quick connect clamp 44. The diverter D is then raised and attached to the rig floor F. Alternatively, the inner barrel IB of the slip joint SJ can be unlocked and the seal housing 20 lifted to the diverter assembly DA, attached by the diverter

D to the rig floor F, with the internal running tool. With the latching and locating pins installed the internal running tool aligns the seal housing 20 and the diverter assembly DA. The seal housing 20 is then clamped to the diverter assembly DA with the quick connect clamp 44 and the latching pins removed. In the embodiment of FIG. 4, the seal housing 20 functions as a passive part of the conventional slip joints/diverter system.

[0028] Alternatively, the seal housing 20 does not have to be installed through the rotary table RT but can be installed using a hoisting cable passed through the rotary table RT. The hoisting cable would be attached to the internal running tool 60 positioned in the housing 20 and, as shown in FIG. 6, the riser guide 68 extending from the crossover 12. Upon positioning of the crossover 12 onto the inner barrel IB, the latching pins 64A, 64B are pulled and the running tool 60 is released. The bearing and seal assembly 10A is then inserted into the housing 20 after the slip joint SJ is locked and the seals in slip joint are fully pressurized. The connector 16, 18 and conduits 30, 32 are then attached to the seal housing 20.

[0029] As can now be understood, the rotatable seals 38, 42 of the assembly 10A seal the rotating tubular 14 and the seal housing 20, and in combination with the flexible conduits 30, 32 connected to a choke manifold CM provide a controlled pressurized mud return system where relative vertical movement of the seals 38, 42 to the tubular 14 are reduced, that is desirable with existing and emerging pressurized mud return technology. In particular, this mechanically controlled pressurized system is particularly useful in underbalanced operations comprising drilling, completions and workovers, gas-liquid and systems and pressurized mud handling systems.

[0030] The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the details of the illustrated apparatus and construction and method of operation may be made without departing from the spirit of the invention.